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FINAL TASK SPECIFIC PLAN FOR SCOPING SURVEY HANGAR 4 NAS BRUNSWICK ME
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TETRA TECH



Final

Task Specific Plan Hangar 4 Scoping Survey

**Naval Air Station Brunswick
Brunswick, Maine**

May 2012

Prepared for:

**Department of the Navy
Base Realignment and Closure
Program Management Office Northeast
Philadelphia, Pennsylvania**

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FINAL

**TASK SPECIFIC PLAN
Hangar 4 SCOPING SURVEY**

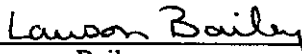
**NAVAL AIR STATION BRUNSWICK
BRUNSWICK, MAINE**

May 2012

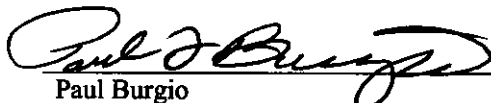
Contract Task Order WE03

**Prepared for:
Department of the Navy
Base Realignment and Closure
Program Management Office Northeast
Philadelphia, Pennsylvania**

REVIEW AND APPROVAL



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ACRONYMS AND ABBREVIATIONS

α	Alpha
β	Beta
ε_i	Instrument efficiency
ε_s	Contaminated surface efficiency
B	Background count rate
b_i	Number of background counts in scan time interval
d'	Index of sensitivity
E	Detector efficiency
G	Source activity
i	Scan or observation interval
ρ or P	Probability
p	Surveyor efficiency factor
R_B	Background count rate
t	Time interval of detector over source
T_B	Background counting time
T_{S+B}	Sample counting time
W_A	Area of the detector window
$Z_{1-\alpha}$	Type I decision error level
$Z_{1-\beta}$	Type II decision error level
cm	Centimeter
cm ²	Square centimeter
cm/sec	Centimeter per second
cpm	Count per minute
Co-60	Cobalt 60
Cs-137	Cesium 137
DU	Depleted Uranium
dpm	Disintegration per minute
DFW	Definable features of work
ft ²	Square feet
HASP	Health and Safety Plan
HRA	Historical radiological assessment
H-3	Tritium
inch/sec	Inch per second
LBGR	Lower bound of the gray region

ACRONYMS AND ABBREVIATIONS (CONTINUED)

MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum detectable concentration
MDCR	Minimum detectable count rate
min	Minute
N	Number of data points
NAS	Naval Air Station
NRC	Nuclear Regulatory Commission
PSPC	Position sensitive proportional counter
Ra-226	Radium 226
RASO	Radiological Affairs Support Office
SCM	Surface contamination monitor
sec	Second
SIMS	Survey Information Management System
Sr-90	Strontium 90
SOP	Standard operating procedure
TSP	Task specific plan
Th-232	Thorium 232
U-238	Uranium 238

1.0 INTRODUCTION

This task specific plan (TSP) provides task-specific details for the scoping survey at Hangar 4 at the Naval Air Station Brunswick (NASB) in Brunswick, Maine. The survey will be conducted in accordance with the general approach and methodologies that are given in the Basewide Radiological Management Plan at Naval Air Station Brunswick ([TetraTech 2012a](#)) and standard operating procedures (SOP). The surveys will conform to the requirements of the Health and Safety Plan (HASP) ([TetraTech 2012b](#)) prepared for the survey program. No exceptions to the management plan, SOPs, and HASP are noted.

1.1 SITE DESCRIPTION AND HISTORICAL SUMMARY

Hangar 4 (Facility 250) is a steel structure on a concrete slab originally constructed in 1956. The hangar was originally connected to the Avionics Shop, Building 250, by an enclosed hallway ([TetraTech 2012c](#)). The building remains undisturbed and is currently vacant. This hangar is approximately 92,220 square feet. From 1956 to base closure on May 31, 2011, Hangar 4 housed P-2 Neptune and P-3 Orion aircraft, squadron work areas, and heavy electronics and maintenance work shops. The Avionics Shop became Aircraft Intermediate Maintenance Department (AIMD), which was responsible for calibration, repair, or replacement of damaged or unserviceable parts, components, or assemblies, limited manufacture of parts, and technical assistance.

Examples of radioactive material used in Hangar 4 are Depleted Uranium (DU) counterweights, infrared detection system turrets, self-illuminating devices and tritium exit signs in the main hangar bay, and self-illuminating devices and electronics containing electron tubes in the Avionics Shop. The isotopes of concern identified in the HRA ([TetraTech 2012c](#)) considered Hangar 4 and Building 250 as a single facility. Additional research and field reconnaissance identified the specific isotopes of concern in Hangar 4 as uranium 238 (U-238), thorium 232 (Th-232), radium 226 (Ra-226) and tritium (H-3) in the main hangar bay and cobalt 60 (Co-60), cesium 137 (Cs-137), strontium 90 (Sr-90), and radium 226 (Ra-226) in the Avionics Shop.

Navy, MRRA and regulatory personnel attended a facility walk-down in April 2012 and were briefed on the methodology for radiologically impacting areas. A more detailed site reconnaissance and review of site drawings and operational history was also performed by the Navy to identify impacted areas requiring surveys. Based on these activities the main hangar area and Room M114 (Avionics Shop) were determined to be impacted.

2.0 SURVEY DESCRIPTION

This survey is being performed to assess if residual activity is above the established release criteria, as defined in Table 6-1 of the management plan ([TetraTech 2012a](#)). Surveys of the facility will be performed to determine the existence of isotopes associated with the maintenance of aircraft and weapons instrumentation. Surveys will be performed for the presence of H-3, Co-60, Cs-137, Sr-90, Ra-226, Th-232 and U-238. Positive indications for beta surveys will be

based on surface contamination monitor (SCM) data indicating measurements outside the normal distribution expected in clean areas and as represented by reference area survey data. The large number of measurements made by the SCM, 400 per square meter, allows identification of small areas not within the normal distribution parameters. The activity levels that are not part of the normal distribution are considered positive indications and will be investigated if investigation levels (defined in [Section 2.4](#)) are exceeded. Due to the extremely low number of counts in the SCM survey interval associated with the release criteria, positive indications for alpha surveys will be based on exceeding a threshold value in both a primary and recount detector in a 100 cm² area. Areas that exceed the investigation criteria based on the activity level determined by the SCM will be investigated.

2.1 SURVEY PREPARATION AND REMEDIATION ACTIVITIES

No preparation of surfaces is required in the main hangar bay of Hangar 4. The surface is exposed concrete. There are some markings on the floor surface to designate aircraft locations, however only a small portion of the surface contains the markings. In the avionics area, flooring will be removed to expose the concrete surface to conduct the required scan and fixed measurement surveys. Materials containing asbestos will be removed by a certified asbestos abatement contractor. Materials (tile, carpet, cabinets, shelving) will be surveyed for release in accordance with SOP-012, *Release of Materials and Equipment* (see Appendix B of the management plan [[TetraTech 2012a](#)]). Materials with radioactivity above the limits specified in Table 6-1 of the management plan will be packaged for storage and subsequent disposal. Materials that cannot be surveyed due to physical size or porosity will be considered potentially radioactive and will be packaged for storage and subsequent evaluation. Survey area preparation activities will be performed under radiological controls established in the SOPs. A listing of applicable SOPs for both preparation and survey activities is provided in [Table 1](#). Surveys conducted in support of area preparation activities can provide input into final reports, but will not be used to demonstrate compliance with the release criteria or determination for additional survey requirements.

2.2 RELEASE CRITERIA

The building surface release criteria for Co-60, Cs-137, and U-238 is 5,000 disintegrations per minute (dpm) per 100 square centimeters (cm²) total activity, for Sr-90 and Th-232 it is 1,000 dpm/100 cm² and for Ra-226 it is 100 dpm/100 cm² ([TetraTech 2012a](#)). The removable contamination release criteria is one-fifth of the total activity limits ([TetraTech 2012a](#)). The limits for the specific radionuclides to be addressed in Hangar 4 are provided in [Table 2](#). Surveys will be performed to meet the more restrictive criteria if more than one beta-emitting or alpha emitting nuclide exists in a survey area. H-3 limits are 5,000 dpm/100 cm² total surface activity, however due to the low energy beta emitted by H-3, detection with surface monitoring is not practical. Smears will be obtained and analyzed at an off-site laboratory for H-3. The release criteria for H-3 will be one fifth of the total activity criteria

2.3 REFERENCE AREA

The reference area will be selected with the concurrence of Navy Radiological Affairs Support Office (RASO). The reference areas for the Hangar 4 survey will consist of concrete floors and sheetrock walls. The reference materials will be identified in on-site buildings that have no history of containing radioactive material. The reference area survey data will be obtained prior to final recording of surveys within Hangar 4 and will be included in the Hangar 4 survey report.

2.4 INVESTIGATION LEVELS

Investigation levels for the alpha and beta surveys will be equal to 75 percent of the release criteria for the more restrictive isotope of concern in each area to be surveyed.

2.5 SURVEY UNITS AND CLASSIFICATION

Hangar 4 will be surveyed as Class 3, requiring a 25 percent survey of floor and walls up to 6 feet. The total floor area of the main hangar bay is 41,950 square feet or 3,900 square meters. An avionics room, room M114, of floor area 402 square feet or 37.4 square meters is located along the east side of the main hangar bay. A layout drawing indicating classification and survey units is provided as [Figure 1](#). Using a random start point, systematic data collection locations (N) will be laid out in a triangular grid pattern for the survey units using the computer process provided by Visual Sample Plan ([Gilbert et al. 2001](#)). In some cases, the number of data collection locations may exceed N. Locations for data collection are provided in [Figures 2](#) through [6](#). Additional biased surveys will be performed and samples will be collected at accessible points of ventilation systems and drain entrances within the building.

2.6 ESTABLISHING THE NUMBER OF MEASUREMENTS

To determine the number of measurements, N, to be taken per survey unit when the contaminant is not present in background, Equation 5-3 of the management plan ([TetraTech 2012a](#)) is used:

Equation 5-3 from the Management Plan ([TetraTech 2012a](#))

$$N = \left(\frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(\text{Sign } \rho - 0.5)^2} \right) (1.2)$$

Where:

N = Number of data points

$Z_{1-\alpha}$ = Type I decision error level, 1.645

$Z_{1-\beta}$ = Type II decision error level, 1.645

$\text{Sign } \rho$ = random measurement probability, 0.945201

1.2 = 20 percent increase in number of samples over the minimum

The values used in the calculation are from Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (Nuclear Regulatory Commission [NRC] 2000) and are based on a recommended value for the relative shift (Δ/σ) of 1.6 as discussed in Section 5.5.2.2 of MARSSIM (NRC 2000). Type I and Type II decision errors are based on 0.05 false negative and 0.05 false positive rates. The associated Z values are obtained from MARSSIM Table 5.2 (NRC 2000). The random measurement probability, Sign ρ , is from MARSSIM Table 5.4 (NRC 2000).

Using the defined values, the equation becomes:

$$N = \left(\frac{(1.645 + 1.645)^2}{4(0.945201 - 0.5)^2} \right) (1.2)$$

The calculation results in a value of $N = 16.38328$. Therefore, a minimum of 17 measurements will be obtained in each survey unit.

2.7 ALPHA AND BETA SCAN MEASUREMENTS

Scan measurements are performed to identify elevated areas of radioactivity within the survey unit. Alpha scans will be effective for identifying elevated concentrations of Ra-226, Th-232 and U-238. Beta scans will be effective in identifying elevated concentrations of Co-60, Cs-137 and Sr-90. Twenty five percent of floor and wall surfaces the Class 3 survey units will be scanned with the SCM or the Ludlum 43-68 gas flow proportional detectors coupled to a Ludlum 2221 or 2241. Based on the identified ROCs, the main hangar bay will be surveyed by an alpha scan. The avionics area will be surveyed by both an alpha and beta scan. All scan surveys will be performed using the Surface Contamination Monitor (SCM).

The SCM utilizes a gas flow position sensitive proportional counter (PSPC). The PSPC functions as any gas flow proportional counter, using P-10 as the counting gas. As in any proportional counter, voltage plateaus are established for the detection of alpha or alpha plus beta particles. High voltage appropriate for the type of particles to be detected is applied to the single anode wire which runs the length of the detector. The SCM computer compares the pulse heights of pulses sensed at each end of the anode wire and establishes the location on the anode wire where the pulsed was sensed. Although the available resolution is greater than 2,000 locations on the anode wire, the SCM computer will “bin” the data in 5 centimeters (cm) wide increments along the length of the wire.

The SCM can be operated in both a dynamic or “rolling” mode or a static or “corner” mode. In the dynamic mode, the system uses a direct current powered drive motor affixed to a cart which contains all electronics and computer hardware, and a detector (or two) is mounted to the front of the cart. The SCM’s design focuses on the elimination of human issues associated with performing surveys of large areas. The system is designed such that surveys are performed at

constant speed, the detector held at a set distance from the surface being surveyed, and survey data recorded automatically. In the dynamic mode, a precision wheel encoder is mounted to the cart axle to determine distance traveled by the cart. The encoder can measure to a small fraction of a centimeter and is used to trigger the computer to capture data for every 5 cm of travel of the SCM cart. The result is count data (counts) for every 5 cm “bin” for every 5 cm of travel, or a matrix of 25 cm² “pixels” of data. In the static mode, a preset time is applied to the collection of data from a stationary detector. Data is binned in a manner similar to the dynamic mode.

Data is transferred from the SCM to a processing station containing the Survey Information Management Systems (SIMS) software via removable media. SIMS software is used to “stitch” the individual strips of data to create a single survey of an entire area. The data collected in 25 cm² “pixels” is summed with adjacent “pixels” in a manner that will result in the evaluation of every possible 100 cm² area. When determining activity, each 25 cm² “pixel” is 25 percent of four overlapping 100 cm² areas. This process ensures that small areas of activity above limits are not missed through grid registration errors.

2.7.1 Alpha Scan Measurements

The SCM will be the primary instrument used to perform alpha surveys. Alpha scans will be performed in the main hangar bay and in the avionics room. The limiting alpha emitting ROC is Ra-226. To achieve the sensitivity to detect at the release criteria for Ra-226, the SCM will be used in the recount mode, using two detectors hard mounted to each other at a set distance. The system will be operated at a target speed of 0.5 inch per second (inch/sec) with detection probability of greater than 95 percent at the release criteria value for Ra-226 of 100 dpm/100 cm² (TetraTech 2012a). The probability of detecting two counts due to a source is given by Equation 7-4 from the Management Plan (TetraTech 2012a) below.

Equation 7-4 from the Management Plan (TetraTech 2012a)

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE + B)t}{60} \right) e^{\frac{-(GE+B)t}{60}}$$

Where:

$P(n \geq 2)$ = probability of getting two or more counts during the time interval t

t = time interval of detector over source (second [sec])

G = source activity (dpm)

E = detector efficiency (4π)

B = background count rate (count per minute [cpm])

60 = conversion factor, seconds to minutes

Since the detectors associated with the SCM are manufactured to the same specifications, the efficiency of each detector is similar. Therefore, the probability of obtaining two or more counts

on each detector as they traverse the same 100 dpm source is the square of the probability for a single detector.

Typical background values observed with the SCM are less than 1 cpm/100 cm². Efficiency (4π) of the SCM for alpha emitters has been measured at 25 percent or greater. The efficiency for a point source would be 50 percent. The detector width is 12 cm. Survey speed for alpha emitters is 1.25 centimeter per second (cm/sec) (0.5 inch/sec). Using these parameters, equation 7-5 from the Management Plan (TetraTech 2012a) becomes:

$$P(n \geq 2) = 1 - \left(1 + \frac{(100 * 0.5 + 1)9.6}{60} \right) e^{\frac{-(100*0.5+1)9.6}{60}}$$

Where:

$P(n \geq 2)$ = probability of getting two or more counts during the time interval t

$t = 9.6$ sec

$G = 100$ dpm

$E = 0.5$

$B = 1$ cpm

Therefore:

$$P(n \geq 2) = 0.9974 \text{ or } 99.74\%$$

The probability of both detectors responding with two or more counts from a point source of 100 dpm at a speed of 1.25 cm/sec (0.5 inch/sec) would be the square of a single detector, or:

$$P(n \geq 2)_{2 \text{ det}} = 99.48\%$$

Therefore, the scan speed for the SCM for alpha emitting nuclides in the avionics room will be 1.25 cm/sec (0.5 inch/sec). If the background observed at the hangar is higher than anticipated, the threshold counts may be raised, provided calculations are performed to show the probability of detecting 100 dpm per 100 cm² and the false positive rate.

For areas that are not surveyed with the SCM due to physical constraints, areas will be scanned with the Ludlum 43-68 gas flow detector and a Ludlum 2221 or 2241 count rate meter. The surveyor will move the detector at a scan speed of 1.25 cm/sec (0.5 inch/sec) at a height of ¼ to ½ inch above the surface while maintaining audio observation of the instrument. A single count will cause the surveyor to pause and observe the area for an additional eight seconds. The probability of getting a second count from a 100 dpm source is given by MARSSIM equation J-5 (NRC 2000):

MARSSIM Equation J-5 (NRC 2000)

$$P(n \geq 1) = 1 - e^{-\frac{(GE+B)t}{60}}$$

Where:

$P(n \geq 1)$ = probability of getting one or more counts during the time interval t

t = time interval of detector over source (sec)

G = source activity (dpm)

E = detector efficiency (4 π)

B = background count rate (cpm)

60 = conversion factor seconds to minutes

Or:

$$P(n \geq 1) = 1 - e^{-\frac{-(100*0.25+1)15.2}{60}}$$

Where:

$P(n \geq 1)$ = probability of getting one or more counts during the time interval t

t = 15.2 sec (based on the initial scan interval of 7.2 seconds plus the 8 second recount)

G = 100 dpm

E = 0.25 (4 π)

B = 1 cpm

Therefore:

$$P(n \geq 1) = 0.999 = 99.9\%$$

If the surveyor does not observe a second count in the eight second window, the surveyor can continue the scan survey. If a second count is observed during the eight second window, the surveyor will obtain a 60 second count at that location and record the data with the direct measurement surveys for the survey unit.

2.7.2 Beta Scan Measurements

Beta scan surveys will be performed in the avionics room. For these beta surveys, the SCM will be the primary instrument. The limiting isotope of concern in the Class 3 area is Co-60. In Class 3 areas, the SCM will be operated at a target speed of 2 inch/sec (5 cm/sec).

For SCM scans for Co-60 in Class 3 areas, the MDCR from Equation 7-5 of the Management Plan (TetraTech 2012a) is:

$$MDCR = 3.28\sqrt{6.67}\left(\frac{60}{2}\right) = 254 \text{ cpm}$$

Where:

$$d' = 3.28$$

$$b_i = 6.67 \text{ counts (based on a 200 cpm background)}$$

$$i = 2 \text{ sec (based on a scan speed of 5 cm/sec and detector width of 10 centimeters)}$$

And the scan MDC from Equation 7-6 of the Management Plan (TetraTech 2012a) is:

$$\text{Scan MDC} = \frac{254}{\sqrt{1} * 0.404 * 0.25 * \frac{100}{100 \text{ cm}^2}} = 2,515 \text{ dpm}$$

Where:

$$p = 1$$

$$\varepsilon_i = 0.404$$

$$\varepsilon_s = 0.25$$

$$W_A = 100 \text{ cm}^2$$

If necessary, for areas that are not surveyed for Co-60 with the SCM due to physical constraints, areas will be scanned with the Ludlum 43-68 gas flow detector and a Ludlum 2221 or 2241 count rate meter. The detector will be operated on the alpha plus beta plateau. The surveyor will move the detector at a scan speed of 0.5 inch/sec (1.25 cm/sec) at a height of ¼ to ½ inch above the surface while maintaining audio observation of the instrument. The response of the Ludlum 43-68 detector to the beta emissions from Co-60 is approximately ½ that of the SCM. Background values are similar. The surveyor efficiency factor is 0.5, detector width is approximately 9 centimeters and the active area of the detector is 126 cm².

For the Ludlum 43-68 detector scans for Co-60 in Class 3 areas the MDCR and Scan MDC are:

$$MDCR = 3.28\sqrt{24}\left(\frac{60}{7.2}\right) = 134 \text{ cpm}$$

Where:

$$d' = 3.28$$

$$b_i = 24 \text{ counts (based on a 200 cpm background)}$$

$i = 7.2$ sec (based on a scan speed of 1.25 cm/sec and a detector width of 9 centimeters)

And:

$$\text{Scan MDC} = \frac{134}{\sqrt{0.5 * 0.202 * 0.25 * \frac{100}{100 \text{ cm}^2}}} = 3,753 \text{ dpm}$$

Where:

$$p = 0.5$$

$$\varepsilon_i = 0.202$$

$$\varepsilon_s = 0.25$$

$$W_A = 126 \text{ cm}^2 \text{ (areas greater than } 100 \text{ cm}^2 \text{ default to } 100 \text{ cm}^2 \text{)}$$

2.8 ALPHA AND BETA STATIC MEASUREMENTS

Alpha and Beta static measurements will be obtained with both the SCM and the Ludlum 43-68 detector coupled to the Ludlum 2221 or 2241 rate meter. The SCM static measurements will supplement the surveys performed in the dynamic or rolling mode when the rolling mode cannot get into areas such as on floors against the wall, or on walls where interferences make rolling surveys impractical. The Ludlum 43-68 detector will be used to obtain fixed measurements at the number of locations identified in [Section 2.5](#).

2.8.1 Alpha Static Measurement MDC

Alpha static measurements will be performed in the main hangar bay and in the avionics room. The limiting alpha emitting ROC is Ra-226. Static counts for alpha emitting Ra-226 obtained with the SCM will utilize the detection probability approach similar to that for the SCM in the dynamic or scan method described in [Section 2.7](#). The SCM will use a single detector; however, 2 data acquisitions of 8 seconds each will be obtained at each location. The surveyor will place the detector against the surface to be surveyed and hold it steady for two 8 second counts. Data will be processed by creating 2 separate surveys of an area, the first 8 second count of each static measurement comprising the first data set and the second 8 second count, the second data set. The second data set will be over-laid on the first, and both sets evaluated for each 100 cm² area. Those areas in which both sets show a positive value above a prescribed threshold, will be indicative of an area in excess of the release criteria. The process assures that areas greater than the release criteria are detected with greater than 95 percent probability while suppressing false positives due to background. The approach is consistent with that of the SCM in the dynamic mode.

The probability of detecting two counts due to a source is given by Equation 7-4 from the management plan ([TetraTech 2012a](#)) below.

Equation 7-4 from the Management Plan (TetraTech 2012a)

$$P(n \geq 2) = 1 - \left(1 + \frac{(GE + B)t}{60} \right) e^{\frac{-(GE+B)t}{60}}$$

Where:

$P(n \geq 2)$ = probability of getting two or more counts during the time interval t

t = time interval of detector over source (sec)

G = source activity (dpm)

E = detector efficiency (4π)

B = background count rate (cpm)

60 = conversion factor, seconds to minutes

Since the same detector will be used to acquire data at each location, all factors are equal for the 2 data sets. Typical background values observed with the SCM are less than 1 cpm/100 cm². Efficiency (4π) of the SCM for alpha emitters has been measured at 25 percent or greater. The efficiency for a point source would be 50 percent. The time interval will be 8 seconds. Using these parameters, equation 7-5 from the management plan (TetraTech 2012a) becomes:

$$P(n \geq 2) = 1 - \left(1 + \frac{(100 * 0.5 + 1)8}{60} \right) e^{\frac{-(100*0.5+1)8}{60}}$$

Where:

$P(n \geq 2)$ = probability of getting two or more counts during the time interval t

t = 8 sec

G = 100 dpm

E = 0.5

B = 1 cpm

Therefore:

$$P(n \geq 2) = 0.9913 \text{ or } 99.13\%$$

The probability of both detectors responding with two or more counts from a point source of 100 dpm with a count time of 8 seconds would be the square of a single detector, or:

$$P(n \geq 2)_{2 \text{ det}} = 98.27\%$$

Therefore, the count time for the SCM in the static mode will be 8 seconds.

Static measurements for alpha emissions in the main hangar bay and avionics area will require a 2 minute count time for the Ludlum 43-68 based on Ra-226. The MDC calculation for the specified count time from Equation 7-8 of the management plan (TetraTech 2012a):

Equation 7-9 from Management Plan (TetraTech 2012a)

$$MDC = \frac{3 + 3.29 \sqrt{1 * 2 * \left(1 + \frac{2}{10}\right)}}{0.25 * 0.25 * \frac{100}{100 \text{ cm}^2} * 2}$$

$$MDC = 64.8 \text{ dpm}$$

Where:

$$R_B = 1 \text{ cpm}$$

$$T_B = 600 \text{ sec or } 10 \text{ min}$$

$$T_{S+B} = 120 \text{ sec or } 2 \text{ min}$$

$$\varepsilon_t = 0.25$$

$$\varepsilon_s = 0.25$$

$$W_A = 126 \text{ cm}^2 \text{ (areas greater than } 100 \text{ cm}^2 \text{ default to } 100 \text{ cm}^2 \text{)}$$

2.8.2 Beta Static Measurement MDC

Static measurement count times for the beta from the limiting ROC, Co-60, will be 8 seconds for the SCM and 30 seconds for the Ludlum 43-68 with the 2221 or 2241 rate meter.

For the SCM surveying for Co-60, the MDC equation becomes:

$$MDC = \frac{3 + 3.29 \sqrt{200 * 0.1333 * \left(1 + \frac{0.1333}{0.1333}\right)}}{0.404 * 0.25 * \frac{100}{100 \text{ cm}^2} * 0.1333} = 2,007 \text{ dpm}$$

Where:

$$R_B = 200 \text{ cpm}$$

$$T_B = 8 \text{ sec or } 0.1333 \text{ min}$$

$$T_{S+B} = 8 \text{ sec or } 0.1333 \text{ min}$$

$$\varepsilon_t = 0.404$$

$$\varepsilon_s = 0.25$$

$$W_A = 100 \text{ cm}^2$$

For the Ludlum 43-68 surveying for Co-60, the equation becomes:

$$MDC = \frac{3 + 3.29 \sqrt{200 * 0.5 * \left(1 + \frac{0.5}{0.5}\right)}}{0.202 * 0.25 * \frac{100}{100 \text{ cm}^2} * 0.5} = 1,961 \text{ dpm}$$

Where:

$$R_B = 200 \text{ cpm}$$

$$T_B = 30 \text{ sec or } 0.5 \text{ min}$$

$$T_{S+B} = 30 \text{ sec or } 0.5 \text{ min}$$

$$\varepsilon_t = 0.202$$

$$\varepsilon_s = 0.25$$

$$W_A = 126 \text{ cm}^2 \text{ (areas greater than } 100 \text{ cm}^2 \text{ default to } 100 \text{ cm}^2)$$

2.9 GAMMA WALKOVER SURVEYS

Gamma walkover surveys will be conducted in each survey unit with a 2" by 2" sodium iodide detector and a Ludlum 2241 ratemeter. Gamma readings will be obtained in accordance with Section 8.2.2 of the Basewide Radiological Management Plan (TetraTech 2012a).

2.10 REMOVABLE CONTAMINATION SURVEYS

Removable contamination will be assessed by swiping a Masslin cloth on a suspect area and monitoring the swiped cloth with a Ludlum 43-68 detector coupled to a Ludlum 2221 or 2241 detector. Since both alpha and beta emitting nuclides are present, detectors will be operated on the both the alpha plateau then on the alpha plus beta plateau. Areas in which the first swipe of the Masslin cloth indicates any increase in activity will be re-wiped with the Masslin cloth to determine the specific area that contains removable contamination. Swipe surveys will be conducted at any area indicating activity above background. Swipe surveys will also be conducted in at least one location within each 1,000 ft² in a Class 3 survey unit, and at each floor and sink drain. Swipe surveys will also be performed at each of the systematic data collection locations. All swipe surveys will be counted using a Ludlum 2929 detector. Swipe surveys will be performed and documented in accordance with SOP-006, *Radiation and Contamination Surveys* (see Appendix B of the management plan [[TetraTech 2012a](#)]).

In addition to swipes to determine the presence of alpha or beta emitting radionuclides, swipes will be taken at the systematic data collection points and drains in the main hangar area for the

presence of H-3. The swipes will be wetted with distilled water prior to survey. Tritium swipes will be sent to an off-site laboratory for analysis using liquid scintillation methods.

2.11 MEDIA SAMPLES

Samples will be collected if sediment is found in sumps, floor drains, and sink drains to support evaluation of compliance with release criteria and to determine specific nuclides as necessary. Sampling may also be performed as an integral part of investigations to determine the cause of elevated measurements. Samples will be collected in accordance with SOP-009, *Sampling Procedures for Radiological Surveys* (see Appendix B of the management plan [[TetraTech 2012a](#)]), and submitted to an off-site laboratory for radiological analysis. One sediment sample per drain will be collected if sediment is present. Analysis of results will be evaluated against soil criteria identified in [Table 2](#).

Media samples will also be obtained at any accessible building outfall locations that would contain liquid runoff from the hangar bay or the avionics room.

3.0 SITE RESTORATION

Site restoration work is not required at the conclusion of surveying in Hangar 4.

4.0 HANGAR 4 REPORT

Results of the survey that demonstrate that no single measurement indicating activity greater than the release criteria, and the resultant risk based dose as calculated, will be presented in a survey report. Any conclusion other than a recommendation for unrestricted release will be presented in a Characterization Report.

5.0 QUALITY CONTROL

The data quality objectives for the survey are provided in [Table 3](#).

Definable features of work (DFW) establish the measures required to verify both the quality of work performed and compliance with project requirements. The DFW for this task is radiological surveys. Description of this DFW and the associated phases of quality control are presented in [Table 4](#).

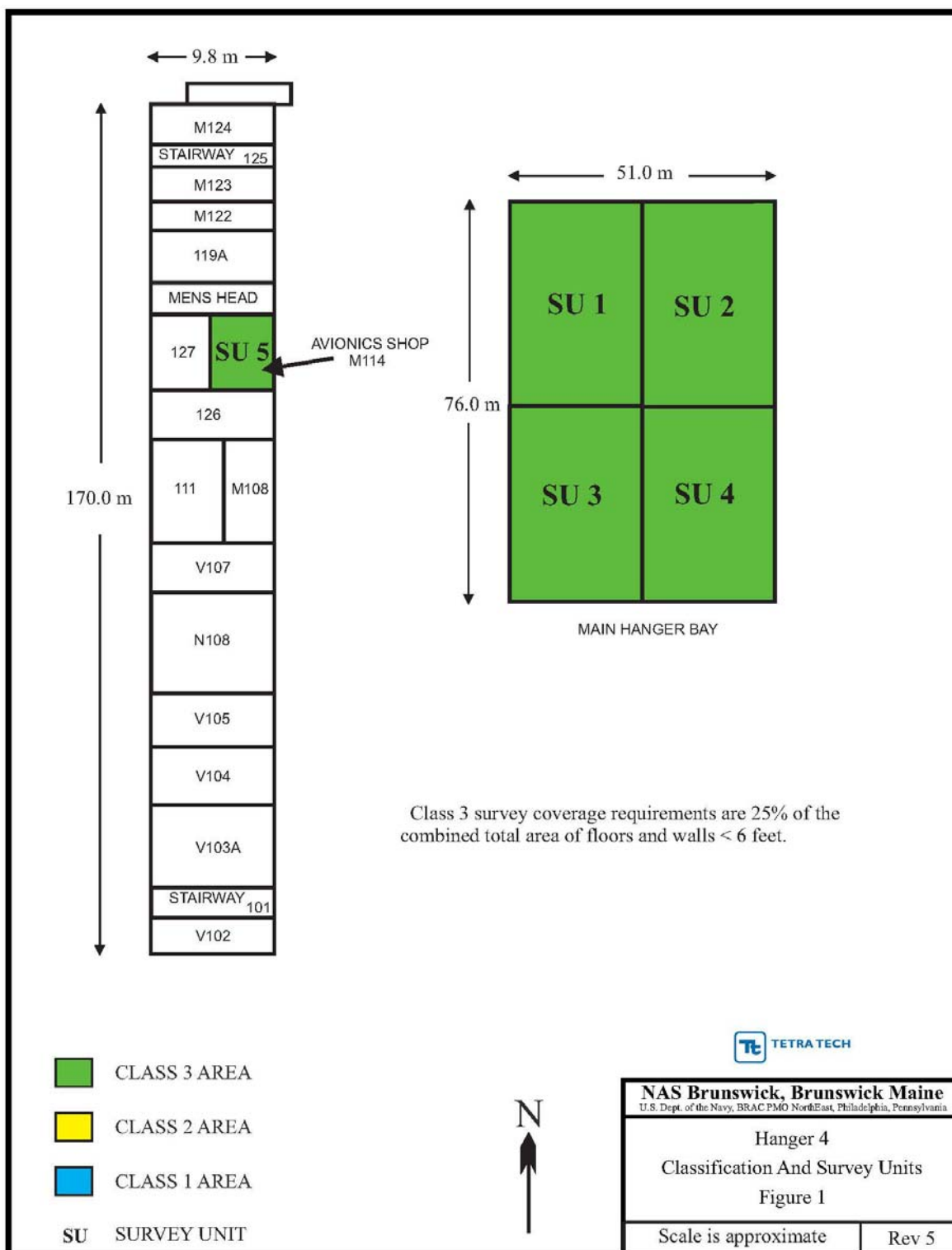
6.0 ENVIRONMENTAL PROTECTION

Environmental protection requirements are addressed in the management plan ([TetraTech 2012a](#)).

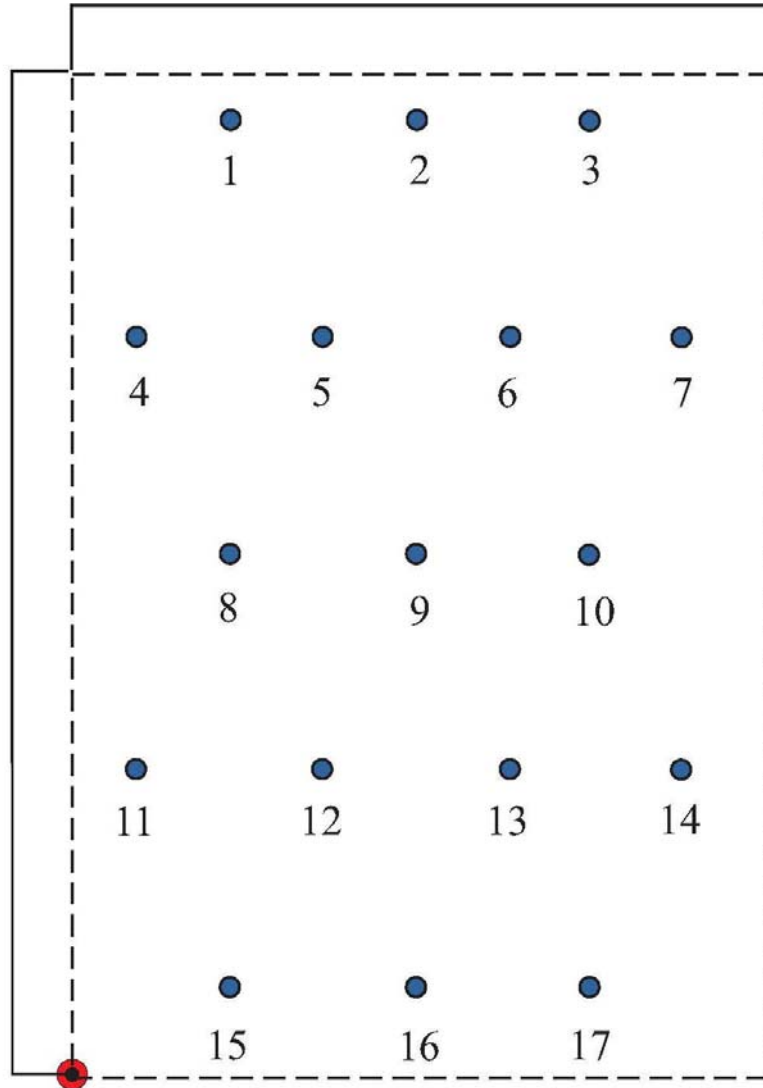
7.0 REFERENCES

- Department of Energy (DOE). 2012. *Visual Sample Plan*. Upgrade version 6.2 released February, 2009. Pacific Northwest National Laboratory.
- Gilbert, R., and others. 2001. *Visual Sample Plan*. Upgrade version 5.9 released October 29, 2009. Pacific Northwest National Laboratory. Principal authors of Version 5.9 Pulsipher, Wilson, and others.
- Nuclear Regulatory Commission (NRC). 2000. NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, Rev. 1.
- Tetra Tech, Inc. (TetraTech) 2012a. *Basewide Radiological Management Plan, Naval Air Station Brunswick, Brunswick, Maine*. April.
- Tetra Tech, Inc. (TetraTech) 2012b. *Health and Safety Plan for Basewide Radiological Surveys, Naval Air Station, Brunswick, Maine*. April.
- Tetra Tech, Inc. (TetraTech) 2012c. *Historical Radiological Assessment, Naval Air Station Brunswick, History of the Use of General Radioactive Materials, 1943-2011*. April.

FIGURES



Floor: 975.5 m²
 Lower walls: 139.4 m²
 Total: 1114.9 m²



Class 3: Floor & Lower Walls

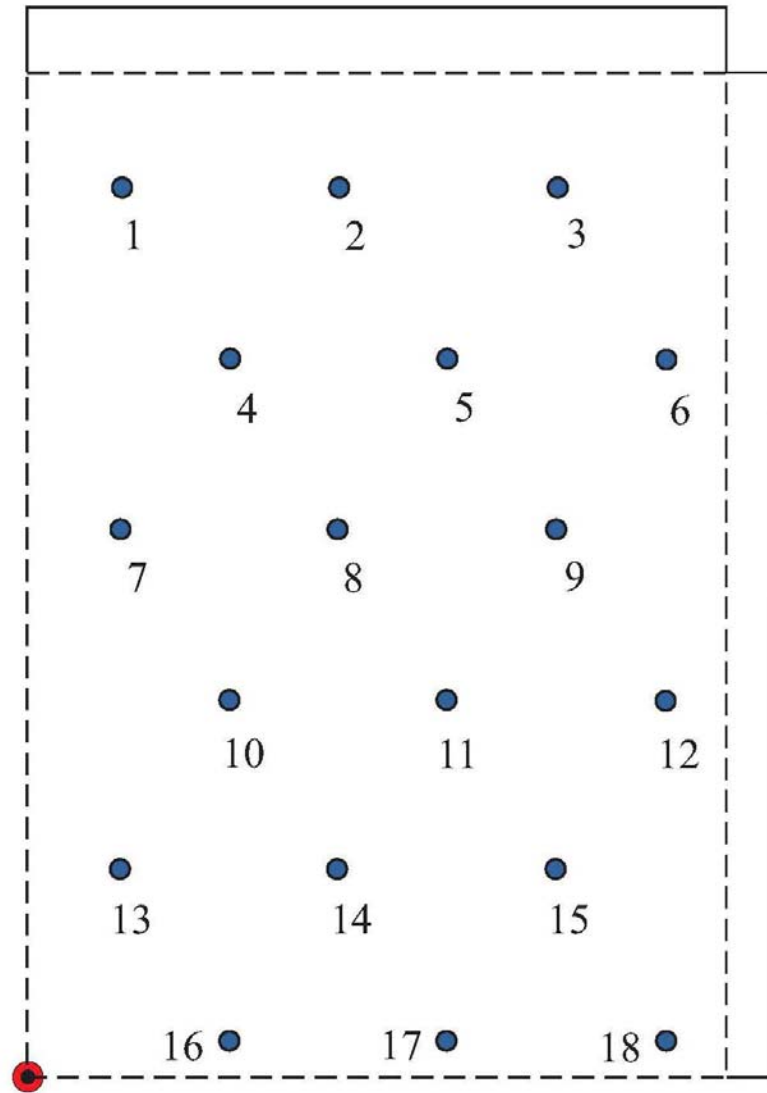


- Sample Point
- South West Corner Reference



NAS Brunswick; Brunswick, Maine <small>U.S. Dept. of the Navy, BRAC PMO Northeast, Philadelphia, Pennsylvania</small>	
Hanger 4 - Survey Unit 1 Open Hanger NW Sample Points Figure 2	
Drawing Not To Scale	Rev 1

Floor: 975.5 m²
 Lower walls: 139.4 m²
 Total: 1114.9 m²



Class 3: Floor & Lower Walls



- Sample Point
- South West Corner Reference



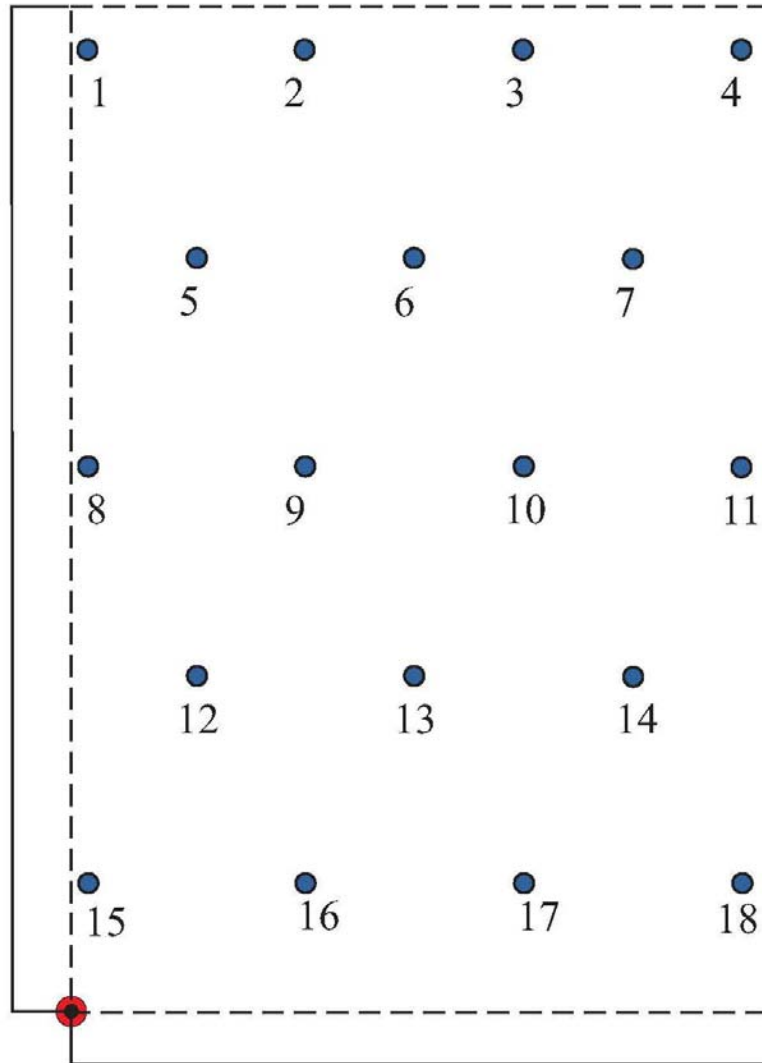
NAS Brunswick; Brunswick, Maine
 U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania

Hanger 4 - Survey Unit 2
 Open Hanger NE
 Sample Points
 Figure 3



Drawing Not To Scale

Rev 1

Floor: 975.5 m²
 Lower walls: 139.4 m²
 Total: 1114.9 m²



Class 3: Floor & Lower walls

-  Sample Point
-  South West Corner Reference



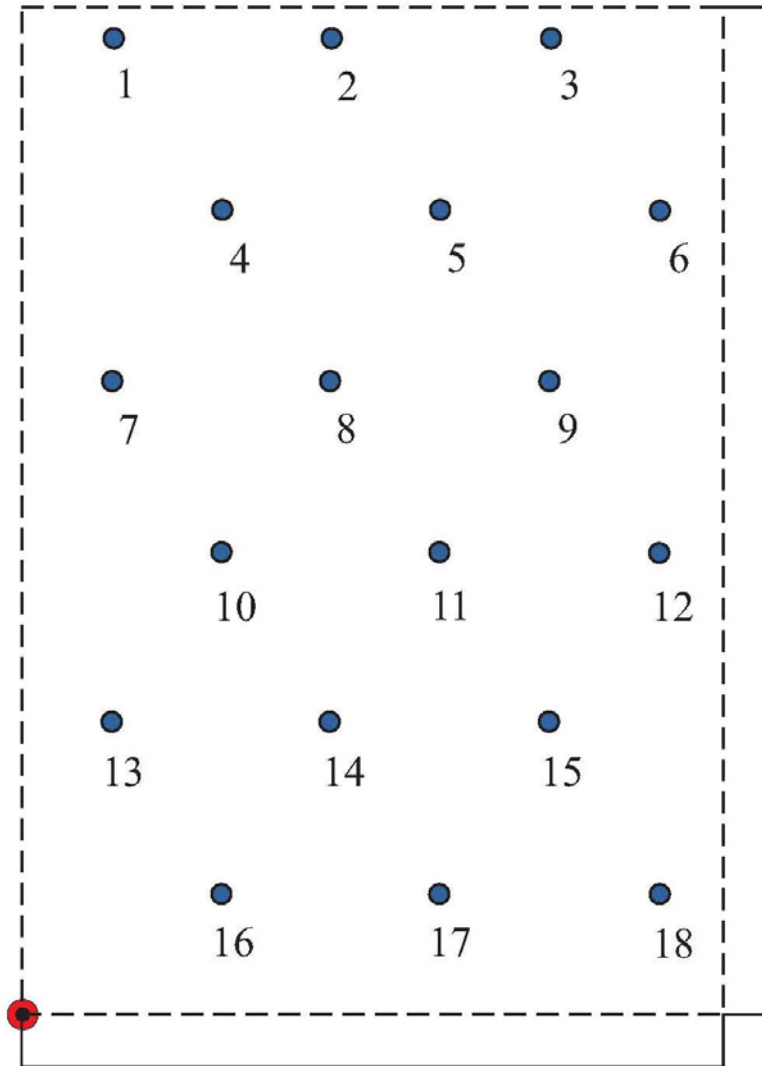
NAS Brunswick; Brunswick, Maine
 U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania

Hanger 4 - Survey Unit 3
 Open Hanger SW
 Sample Points
 Figure 4

Drawing Not To Scale

Rev 1

Floor: 975.5 m²
 Lower walls: 139.4 m²
 Total: 1114.9 m²



Class 3: Floor & Lower Walls



- Sample Point
- South West Corner Reference



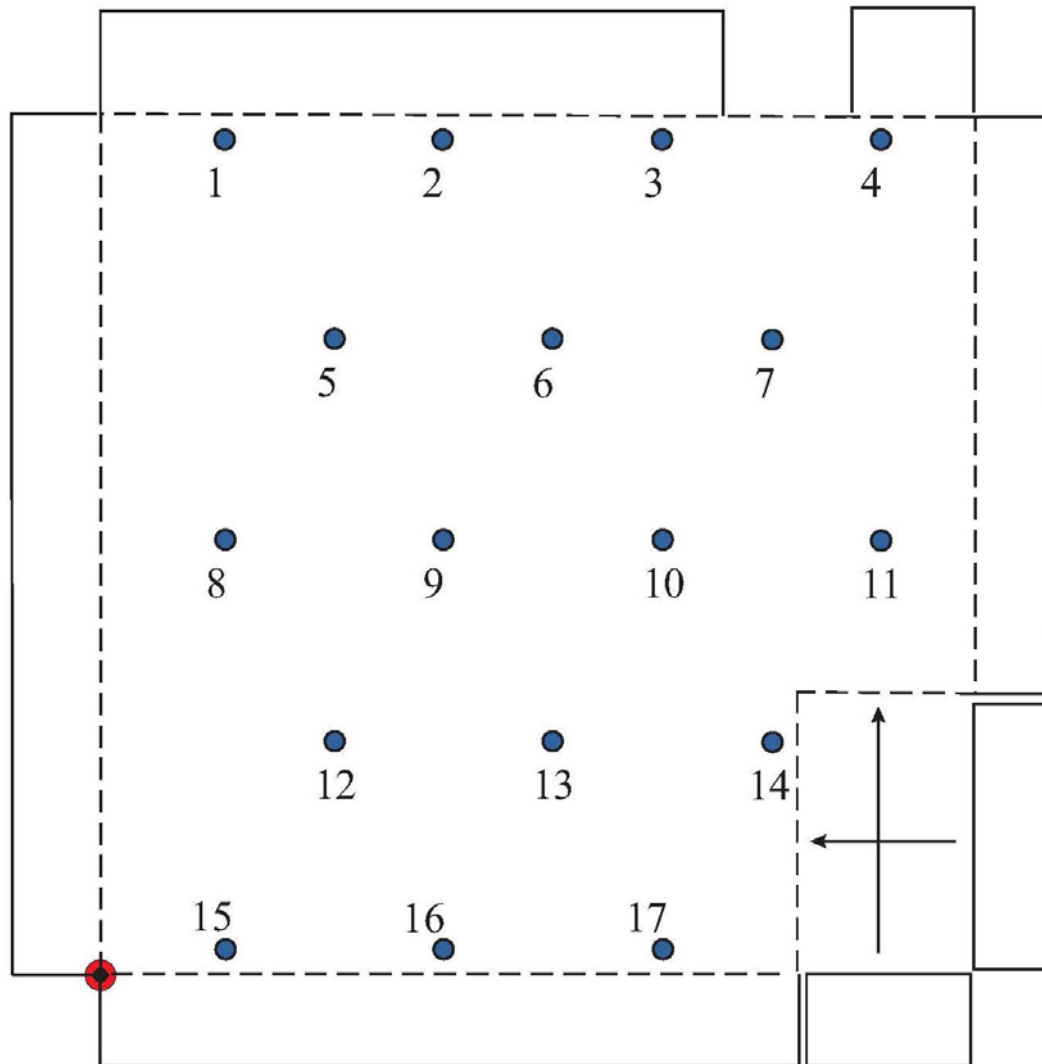
NAS Brunswick; Brunswick, Maine
 U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania

Hanger 4 - Survey Unit 4
 Open Hanger SE
 Sample Points
 Figure 5

Drawing Not To Scale

Rev 1

Floor: 24.2 m²
 Lower walls: 37.36 m²
 Total: 61.56 m²



Class 3: Floor & Lower Walls



- Sample Point
- South West Corner Reference



NAS Brunswick; Brunswick, Maine
 U.S. Dept. of the Navy, BRAC PMO NorthEast, Philadelphia, Pennsylvania

Hanger 4 - Survey Unit 5
 Rm 114 Avionics Shop
 Sample Points
 Figure 6

Drawing Not To Scale

Rev 1

TABLES

TABLE 1 HANGAR 4 APPLICABLE STANDARD OPERATING PROCEDURES

Procedure	Title	Rev
SOP 002	Radiation Work Permits	0
SOP 004	Project Dosimetry	0
SOP 006	Radiation and Contamination Surveys	0
SOP 007	Preparation of Portable Radiation and Contamination Survey Meters for Field Use	0
SOP 008	Air Sampling and Sample Analysis	0
SOP 009	Sampling Procedures for Radiological Surveys	0
SOP 010	RCA Posting and Access Control	0
SOP 011	Control of Radioactive Materials	0
SOP 012	Release of Materials and Equipment	0
SOP 016	Decontamination of Equipment and Tools	0
SOP 022	Radiological Clothing Selection, Monitoring and Decontamination	0
SOP 023	Source Control	0
SOP 024	Occurrence Reporting	0
RP-OP-017	Operation of the Ludlum Model 2929 Dual Scaler	0
RP-OP-025	Operation of the Ludlum Model 2221	0
RP-OP-026	Operation of the Ludlum Model 19	0
SCM-OPS-01	Position Sensitive Proportional Counters Purging	0
SCM-OPS-02	Position Sensitive Proportional Counters Plateau Determination	0
SCM-OPS-03	Position Sensitive Proportional Counters Position Calibration	1
SCM-OPS-04	Encoder Calibration	0
SCM-OPS-05	Position Sensitive Proportional Counters Efficiency Calibration	0
SCM-OPS-06	Position Sensitive Proportional Counters Quality Assurance	1
SCM-SETUP-01	Position Sensitive Proportional Counters Repair	0
SCM-SETUP-02	Hardware Setup	0
SCM-SETUP-03	Quality Assurance Testing of SCM	0

TABLE 2 HANGAR 4 PRIMARY RADIATION PROPERTIES AND RELEASE CRITERIA FOR RADIONUCLIDES OF CONCERN

Radionuclide	Primary Radiation Properties		Release Criteria ^a				
	Half-Life	Type	Materials & Equipment		Building Surfaces		Soil ^b
			Total Surface Activity	Removable Activity	Total Surface Activity	Removable Activity	Activity (pCi/g)
H-3	1.23E01 years	Beta	5,000	1,000	5,000	1,000	66
Co-60	5.27E00 years	Beta	5,000	1,000	5,000	1,000	2.28
Cs-137	3.00E01 years	Beta	5,000	1,000	5,000	1,000	6.6
Sr-90	2.77E01 years	Beta	1,000	200	1,000	200	1.02
Ra-226	1.60E03 years	Alpha	100	20	100	20	1.0
Th-232	1.40E10 years	Alpha	5,000	1,000	5,000	1,000	0.66
U-238	4.47E09 years	Alpha/Beta	5,000	1,000	5,000	1,000	8.4

Notes:

a Units are disintegrations per minute per 100 square centimeters, unless otherwise specified.

b Criteria is above background for those radionuclides found in background soils.

Source: [TetraTech 2012a](#). Basewide Radiological Management Plan, Naval Air Station Brunswick, Brunswick, Maine. April.

TABLE 3 SUMMARY OF DATA QUALITY OBJECTIVES

STEP 1 Statement of Problem	STEP 2 Decisions	STEP 3 Inputs to the Decisions	STEP 4 Boundaries of Study	STEP 5 Decision Rules	STEP 6 Limits on Decision Errors	STEP 7 Optimizing the Sampling Design
<p>Hangar 4 is listed in the HRA as an area impacted by radiological activities. The isotopes of concern are DU, Th-232, Ra-226 and H-3 in the main hangar bay and Co-60, Cs-137, Sr-90 and Ra-226 in the Avionics Shop.</p> <p>It must be determined if the site-specific release criteria for these isotopes have been met or if remediation or further survey is warranted.</p>	<p>The primary use of the data expected to result from completion of this TSP is to support the Scoping Survey of Hangar 4.</p> <p>Therefore the decision to be made can be stated as “Do the results of the survey indicate activity above background or meet the release criteria?”</p>	<p>Radiological surveys required to support the Final Status Survey of Hangar 4 will include:</p> <ul style="list-style-type: none"> • 25 percent scan surveys of Class 3 areas • A minimum of 17 systematic static measurements will be performed in Class 3 areas • One swipe per 1,000 square feet in Class 3 survey units • One sediment sample will be collected from each drain if available. • One swipe at each systematic sample location • One tritium swipe at each systematic location in the main hangar bay 	<p>The lateral and vertical spatial boundaries for this survey effort are confined to the interior portions of the main hangar bay and the avionics room, Room #114 of Hangar 4.</p>	<p>If the concentration of radioactivity on building surfaces, paved areas, or in sediment samples is less than the release criteria, then no further measurements are required.</p> <p>If the results of the survey exceed the release criteria, then the building will be investigated further.</p>	<p>Limits on decision errors are set at 5 percent as specified in the management plan (TetraTech 2012a).</p>	<p>Operational details for the radiological survey process have been developed. The theoretical assumptions are based on guidelines contained in MARSSIM (NRC 2000). Specific assumptions regarding types of radiation measurements, instrument detection capabilities, quantities and locations of data to be collected, and investigation levels are contained in this TSP and the management plan (TetraTech 2012a).</p>

Notes:

Cs-137 Cesium 137
 Co-60 Cobalt 60
 DU Depleted uranium
 H-3 Tritium
 HRA Historical Radiological Assessment
 MARSSIM Multi-Agency Radiation Survey and Site Investigation Manual

NRC Nuclear Regulatory Commission
 Ra-226 Radium 226
 Sr-90 Strontium 90
 Th-232 Thorium 232
 TSP Task Specific Plan

TABLE 4 DEFINABLE FEATURES OF WORK FOR RADIOLOGICAL SURVEYS

ACTIVITY	PREPARATORY (Prior to initiating survey activity)	DONE	INITIAL (At onset of survey activities)	DONE	FOLLOW-UP (Ongoing during survey activities)	DONE
Radiological Surveys	<ul style="list-style-type: none"> • Verify that an approved TSP is in place. • Verify that the Remedial Project Manager and the Caretaker Site Office are notified about mobilization. • Verify that an approved Radiation Work Permit, if required, is available and has been read and signed by assigned personnel. • Verify that the management plan, HASP and TSP, have been reviewed. • Verify that personnel assigned are trained and qualified. • Verify that personnel have been given an emergency notification procedure. • Verify that workers assigned dosimeter have completed NRC Form 4. • Verify that relevant SOPs are available and have been reviewed for equipment to be used. • Verify that equipment is on site and in working order (initial daily check). 		<ul style="list-style-type: none"> • Verify that radiological instruments are as specified in the management plan (TetraTech 2012a) and TSP. • Inspect Training Records. • Verify that reference area measurements have been obtained in accordance with the management plan (TetraTech 2012a). • Verify that daily checks were performed on all survey instruments. • Verify that instrument calibration and setup are current. • Verify that required dosimeter is being worn. • Verify that field logbooks and proper forms are in use. • Verify that samples and measurements are being collected in accordance with the TSP, management plan and applicable SOPs. • Verify the sample handling is in accordance with the management plan (TetraTech 2012a) and applicable SOPs. 		<ul style="list-style-type: none"> • Verify that the site is properly posted and secured. • Conduct ongoing inspections of material and equipment. • Verify that daily instrument checks were obtained and documented. • Verify that survey results were documented. • Inspect chain-of-custody and survey logs for completeness. • Verify that survey activities conform to the TSP. • Verify that survey instruments are recalibrated after repairs or modifications. 	

Notes:

HASP Health and Safety Plan
NRC Nuclear Regulatory Commission
SOP Standard Operating Procedure
TSP Task Specific Plan